

PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference K3245-PCT	FOR FURTHER ACTION		See Form PCT/IPEA/416
International application No. PCT/BE2005/000031	International filing date (day/month/year) 25.02.2005	Priority date (day/month/year) 26.02.2004	
International Patent Classification (IPC) or national classification and IPC INV. A61B5/103 G06T15/70			
Applicant K.U. LEUVEN RESEARCH & DEVELOPMENT et al.			
<p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 9 sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p>a. <input checked="" type="checkbox"/> (<i>sent to the applicant and to the International Bureau</i>) a total of 5 sheets, as follows:</p> <ul style="list-style-type: none"> <input checked="" type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions). <input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box. <p>b. <input type="checkbox"/> (<i>sent to the International Bureau only</i>) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p>			
<p>4. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Box No. I Basis of the report <input type="checkbox"/> Box No. II Priority <input checked="" type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability <input checked="" type="checkbox"/> Box No. IV Lack of unity of invention <input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement <input type="checkbox"/> Box No. VI Certain documents cited <input type="checkbox"/> Box No. VII Certain defects in the international application <input type="checkbox"/> Box No. VIII Certain observations on the international application 			
Date of submission of the demand 13.01.2006	Date of completion of this report 02.06.2006		
Name and mailing address of the international examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Willig, H Telephone No. +49 89 2399-7464		



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Box No. I Basis of the report

1. With regard to the **language**, this report is based on
 - the international application in the language in which it was filed
 - a translation of the international application into , which is the language of a translation furnished for the purposes of:
 - international search (under Rules 12.3(a) and 23.1(b))
 - publication of the international application (under Rule 12.4(a))
 - international preliminary examination (under Rules 55.2(a) and/or 55.3(a))
2. With regard to the **elements*** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

Description, Pages

1-31 as originally filed

Claims, Numbers

1-27 filed with telefax on 09.05.2006

Drawings, Sheets

1/13-13/13 as originally filed

a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. The amendments have resulted in the cancellation of:
 - the description, pages
 - the claims, Nos.
 - the drawings, sheets/figs
 - the sequence listing (*specify*):
 - any table(s) related to sequence listing (*specify*):
4. This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
 - the description, pages
 - the claims, Nos.
 - the drawings, sheets/figs
 - the sequence listing (*specify*):
 - any table(s) related to sequence listing (*specify*):

* If item 4 applies, some or all of these sheets may be marked "superseded."

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Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

- the entire international application,
 claims Nos. 25-27

because:

- the said international application, or the said claims Nos. 25-27 relate to the following subject matter which does not require an international preliminary examination (*specify*):

see separate sheet

- the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):
- the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed (*specify*):
- no international search report has been established for the said claims Nos.
- a meaningful opinion could not be formed without the sequence listing; the applicant did not, within the prescribed time limit:
 - furnish a sequence listing on paper complying with the standard provided for in Annex C of the Administrative Instructions, and such listing was not available to the International Preliminary Examining Authority in a form and manner acceptable to it.
 - furnish a sequence listing in electronic form complying with the standard provided for in Annex C of the Administrative Instructions, and such listing was not available to the International Preliminary Examining Authority in a form and manner acceptable to it.
 - pay the required late furnishing fee for the furnishing of a sequence listing in response to an invitation under Rules 13ter.1(a) or (b) and 13ter.2.
- a meaningful opinion could not be formed without the tables related to the sequence listings; the applicant did not, within the prescribed time limit, furnish such tables in electronic form complying with the technical requirements provided for in Annex C-bis of the Administrative Instructions, and such tables were not available to the International Preliminary Examining Authority in a form and manner acceptable to it.
- the tables related to the nucleotide and/or amino acid sequence listing, if in electronic form only, do not comply with the technical requirements provided for in Annex C-bis of the Administrative Instructions.
- See separate sheet for further details

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Box No. IV Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees, the applicant has, within the applicable time limit:
 - restricted the claims.
 - paid additional fees.
 - paid additional fees under protest and, where applicable, the protest fee.
 - paid additional fees under protest but the applicable protest fee was not paid.
 - neither restricted the claims nor paid additional fees.
2. This Authority found that the requirement of unity of invention is not complied with and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.
3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is:
 - complied with.
 - not complied with for the following reasons:
4. Consequently, this report has been established in respect of the following parts of the international application:
 - all parts.
 - the parts relating to claims Nos. 1-15,25-27 .

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N) Yes: Claims 1-15

No: Claims

Inventive step (IS) Yes: Claims

No: Claims 1-15

Industrial applicability (IA) Yes: Claims 1-15

No: Claims

2. Citations and explanations (Rule 70.7):

see separate sheet

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Reference is made to the following documents:

- D1: US 2002/009222 A1 (MCGIBBON CHRIS A ET AL) 24 January 2002 (2002-01-24)
- D2: LI ZHANG ET AL: "Spacetime stereo: shape recovery for dynamic scenes" PROCEEDINGS 2003 IEEE CONFERENCE ON COMPUTER VISION AND PATTERN RECOGNITION. CVPR 2003. MADISON, WI, JUNE 18 - 20, 2003, PROCEEDINGS OF THE IEEE COMPUTER CONFERENCE ON COMPUTER VISION AND PATTERN RECOGNITION, LOS ALAMITOS, CA, IEEE COMP. SOC, US, vol. VOL. 2 OF 2, 18 June 2003 (2003-06-18), pages 367-374, XP010644695 ISBN: 0-7695-1900-8
- D4: LI ZHANG ET AL: "Rapid shape acquisition using color structured light and multi-pass dynamic programming" 3D DATA PROCESSING VISUALIZATION AND TRANSMISSION, 2002. PROCEEDINGS. FIRST INTERNATIONAL SYMPOSIUM ON JUNE 19-21, 2002, PISCATAWAY, NJ, USA, IEEE, 19 June 2002 (2002-06-19), pages 24-36, XP010596631 ISBN: 0-7695-1521-4
- D5: US-B1-6 373 963 (DEMERS MICHELLE H ET AL) 16 April 2002 (2002-04-16)
- D6: KERVRANN C ET AL: "A Hierarchical Markov Modeling Approach for the Segmentation and Tracking of Deformable Shapes" CVGIP GRAPHICAL MODELS AND IMAGE PROCESSING, ACADEMIC PRESS, DULUTH, MA, US, vol. 60, no. 3, May 1998 (1998-05), pages 173-195, XP004418894 ISSN: 1077-3169
- D10: DRERUP B ET AL: "BACK SHAPE MEASUREMENT USING VIDEO RASTERSTEREOGRAPHY AND THREE- DIMENSIONAL RECONSTRUCTION OF SPINAL SHAPE" CLINICAL BIOMECHANICS, BUTTERWORTH SCIENTIFIC LTD, GUILDFORD, GB, vol. 9, no. 1, January 1994 (1994-01), pages 28-36, XP000418363 ISSN: 0268-0033

Re Item III

Claims 25-27 are considered to relate to a computer programm (Rule 67.1(vi) PCT).

Therefore, an opinion with respect to novelty, inventive step and industrial applicability is not established for **claims 25-27** (Art. 34(4)(a)(i) PCT).

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Re Item IV

The application comprises the following three inventions.

Invention 1: Claims 1-15

Reconstructing internal structures based on time-dependent optical 3 dimensional images of the surface of a part of a body.

Invention 2: Claims 16-19

Determination of anatomical landmarks and shapes in time-dependent images of the surface of a part of a body.

Invention 3: Claims 20-24

Constructing a time-dependent 3-dimensional biomechanical model of a musculo-skeletal structure from time-dependent anatomical surface information.

The three inventions lack unity according to Art. 13 PCT. The reasons are as follows.

Obtaining time-dependent surface images or information and processing such images of information is already known in the state of the art; see for instance, document D2, which is related to shape recovery in stereo images (see, e.g. section "1. Introduction").

The contributions of the three inventions over the prior art reside in the reconstruction of internal structures, the determination of anatomical landmarks and the construction of a biomechanical model, respectively. There is apparently no relationship among the above three inventions involving same or corresponding special technical features in the sense of Rule 13.2 PCT. Therefore, the three inventions are not so linked as to form a single general inventive concept according to Rule 13.1 PCT.

Re Item V

- 1 The subject-matter of independent **claims 1 and 13** lacks an inventive step according to Art. 33(3) PCT. The reasons are as follows.

Document D10, which is considered as closest prior art document for the first

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invention, discloses a computer based method for obtaining a musculo-skeletal model of a part of a body of a creature from optical 3 dimensional images of the surface of a part of the body of the creature (see summary), the method comprising

- (a) detecting anatomical surface information based on a topography of the surface in the 3 dimensional optical images of the surface of the part of the body of the creature obtained in a contact-free manner (see p. 29, left col., 2nd para., section "Video rasterstereography" starting on p. 29, left col.),
- (b) reconstructing internal structures based on the detected anatomical surface information (see p. 29, left col., 2nd para., section "Method of back shape analysis" starting on p. 30, left col.),

wherein the musculo-skeletal model is obtained without the use of synthetic markers attached to the surface of the body (see p. 29, left col., 2nd para.).

Document D10 necessarily also discloses a system for performing the method.

The difference between the invention and the closest prior art is that a series of time-dependent images is used.

Accordingly, with the invention, a non-static model, i.e. a model for a series of time points during a movement of the creature, can be obtained.

For the person skilled in the art it is immediately apparent that, for this purpose, a series of images has to be taken during a movement of the creature. For this reason, the subject-matter of **claims 1 and 13** is considered obvious for the persons skilled in the art.

For the sake of completeness the following is noted: Document D1 discloses a method and system for obtaining a kinematic, i.e. non-static musculo-skeletal model of a creature (see abstract). According to para. 0021-0023, for this purpose, the movement of the creature is recorded with a set of cameras, i.e. a series of time-dependent images is acquired. Therefore, the subject-matter of **claims 1 and 13** is obvious for the person skilled in the art also in view of a combination of documents D10 and D1.

- 2 Dependent **claims 2-15** do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in

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respect of inventive step according to Art. 33(3) PCT. The reasons are as follows.

The additional features of **claims 2, 4, 6, 10-12, 14 and 15** are also known from document D10 (see summary, p. 29, left col., 2nd para., p. 31, right col., subsection "Anatomical landmarks").

Raster line triangulation (**claim 3**) as technique for obtaining 3 dimensional images is known from and obvious in view of document D4 (see section "3. Multi-hypothesis code matching").

Taking images of the size claimed in **claim 5** is obvious in view of document D5.

Claims 7-9: The use of active contour or shape modelling for detecting the anatomical surface information is considered obvious in view of document D6 (see section "2. Background and related work").

CLAIMS

1. A computer based method (100) for obtaining a musculo-skeletal model (240) of at least part of a body of a creature from a series of time-dependent optical 3 dimensional images of the surface of said at least part of a body of a creature, the method comprising
 - detecting (104) anatomical surface information (220) based on a topography of the surface in said series of time dependent optical 3 dimensional images of the surface of said at least part of a body of a creature obtained in a contact-free manner, and
 - reconstructing (106) internal structures (230) based on said detected anatomical surface information (220), wherein said musculo-skeletal model is obtained without the use of synthetic markers attached to the surface of the body.
- 15 2. A method (100) according to the previous claim, wherein said series of time-dependent optical 3 dimensional images of the surface of said at least part of a body of a creature obtained in a contact-free manner is provided using structured light projection.
- 20 3. A method (100) according to any of the previous claims, wherein said series of time-dependent optical 3 dimensional images of the surface of said at least part of a body of a creature obtained in a contact-free manner is provided using raster line (170) triangulation.
- 25 4. A method (100) according to any of the previous claims, wherein said series of time-dependent optical 3 dimensional images of the surface of said at least part of a body of a creature obtained in a contact-free manner is provided using stereoscopic techniques.
- 30 5. A method (100) according to any of the previous claims, wherein said series of time-dependent optical 3 dimensional images of the surface of at least part of said body of a creature obtained in a contact-free manner is provided by obtaining said 3 dimensional images whereby each of a width, height and depth of said 3 dimensional images can have a length up to 1,2 m.

6. A method (100) according to any of the previous claims, wherein said time-dependent 3 dimensional image of the surface of said at least part of the body of a creature obtained in a contact-free manner is provided using a multi-view system.
- 5 7. A method (100) according to any of the previous claims, wherein said detecting (104) anatomical surface information (220) based on a topography of the surface in said series of time-dependent optical 3 dimensional images is obtained by active contour modelling.
8. A method (100) according to claim 7, wherein said active contour modelling is based on optimising a finite number of active contour points, whereby all active contour points substantially being at an equal distance.
- 10 9. A method (100) according to any of the previous claims, wherein said detecting (104) anatomical surface information (220) based on the topography of the surface in said series of time-dependent optical 3 dimensional image is obtained by active shape modelling.
- 15 10. A method (100) according to any of the previous claims, wherein said reconstructing (106) internal structures (230) comprises at least one of the group of bones, ligaments, tendons and muscles.
11. A method (100) according to any of the previous claims, wherein said anatomical surface information (220) are landmarks.
- 20 12. A method for collecting data suitable for diagnostics of disorders in creatures, comprising building a computer based musculo-skeletal model (240) obtained according to a method (100) of any of the previous claims.
13. A system for obtaining a musculo-skeletal model (240) of at least part of a creature, the system comprising
 - 25 - means for providing a series of time-dependent optical 3 dimensional images of a surface of said at least part of a body of a creature obtained in a contact-free manner,
 - means for detecting anatomical surface information (220) on said series of time dependent optical 3 dimensional images of a surface of said at least part of a body of a creature obtained in a contact-free manner,
- 30 and

- means for reconstructing internal structures (230) based on said detected anatomical surface information (220) wherein the system is adapted to obtain the musculo-skeletal model without the use of synthetic markers attached to the surface of the body.
- 5 14. A system according to claim 13, wherein said means for providing a series of time-dependent optical 3 dimensional images of a surface of said at least part of a body of a creature obtained in a contact free manner comprises a means for obtaining in a contact free manner optical 3 dimensional images of the surface of said at least part of a body of a creature.
- 10 15. A system according to any of claims 13 to 14, wherein said anatomical surface information (220) are landmarks.
- 15 16. A computer based method for detecting and/or extracting from a series of time-dependent images of a surface of body parts of a creature anatomical features on surface measurements, said method comprising using invariant feature analysis to determine anatomical landmarks and shapes,
wherein said invariant feature analysis comprises fulfilling predetermined conditions describing topographic characteristics of the surface of the body parts of the creature and fulfilling predetermined conditions describing topographic, topologic and/or volumetric characteristics of the interior of the body parts of the creature.
- 20 17. A computer based method according to claim 16, wherein said topographic characteristics of the surface of the body parts of the creature are at least one of curvature and symmetry of surface parts of the body parts of the creature and wherein said topographic, topologic and/or volumetric characteristics of the interior of the body parts of a creature are at least one of the relative position, bending, torsion, equidistance and dynamical properties of interior parts of the body parts of the creature.
- 25 18. A method according to claim 17, wherein said topographic characteristics of the surface of the body parts of the creature are curvature and symmetry of surface parts of the body parts of the creature and said topographic, topologic and/or volumetric characteristics of the interior of the

body parts of a creature are the relative position, bending, torsion, equidistance and dynamical properties of interior parts of the body parts of the creature.

19. A method according to any of claims 16 to 18 wherein said predetermined conditions describing topographic characteristics of the surface of the body parts of the creature and said predetermined conditions describing topographic, topologic and volumetric characteristics of the interior of the body parts of the creature are determined by biomechanical constraints.
- 10 20. A computer based method for constructing a time-dependent 3-dimensional biomechanical model of a musculo-skeletal structure of at least part of a body of a creature from time-dependent anatomical surface information, said method comprising
 - determining from said time-dependent anatomical surface information a set of boundary conditions for a time-dependent 3-dimensional biomechanical model of a musculo-skeletal structure, and
 - fitting a time-dependent 3-dimensional bio-mechanical model of a musculo-skeletal structure according to said set of boundary conditions, wherein said anatomical surface information comprises both landmarks and surface shapes.
21. A computer based method according to claim 20, wherein said method furthermore comprises initially scaling and calibrating said bio-mechanical model of a musculo-skeletal structure based on anatomical surface information obtained for said at least part of a body of a creature in a predefined position.
- 25 22. A computer based method according to any of claims 20 to 21, wherein said method furthermore comprises, after fitting a biomechanical model of a musculo-skeletal structure, checking the plausibility of said biomechanical model of a musculo-skeletal structure with respect to biomechanical constraints.
- 30 23. A computer based method according to any of claims 20 to 22, wherein said method furthermore comprises, after fitting a biomechanical model of a musculo-skeletal structure according to said set of boundary conditions,

dynamically adjusting and refining said biomechanical model of a musculo-skeletal structure from repeatedly obtained new time-dependent anatomical surface information, by repeatedly

- determining the new boundary conditions for a biomechanical model of a musculo-skeletal structure based on said new time-dependent anatomical surface shape information, and
 - adjusting said biomechanical model of a musculo-skeletal structure according to said set of new boundary conditions.
24. A computer based method of extended modelling of kinematics, kinetics and dynamics of the musculo-skeletal system of a moving body comprising extraction of relevant parameters from the bio-mechanical model according to any of claims 20 to 23.
25. A computer program product for executing the method as claimed in any of claims 1 to 12 or 16 to 24.
- 15 26. A machine readable data storage device storing the computer product of claim 25.
27. Transmission of the computer program product of claim 25 over a local or wide area telecommunications network.